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SURFACE PREPARATION AND COATINGS
DESIGN/PRODUCTION INTEGRATION
HUMAN RESOURCE INNOVATION
MARINE INDUSTRY STANDARDS
WELDING
INDUSTRIAL ENGINEERING
EDUCATION AND TRAINING

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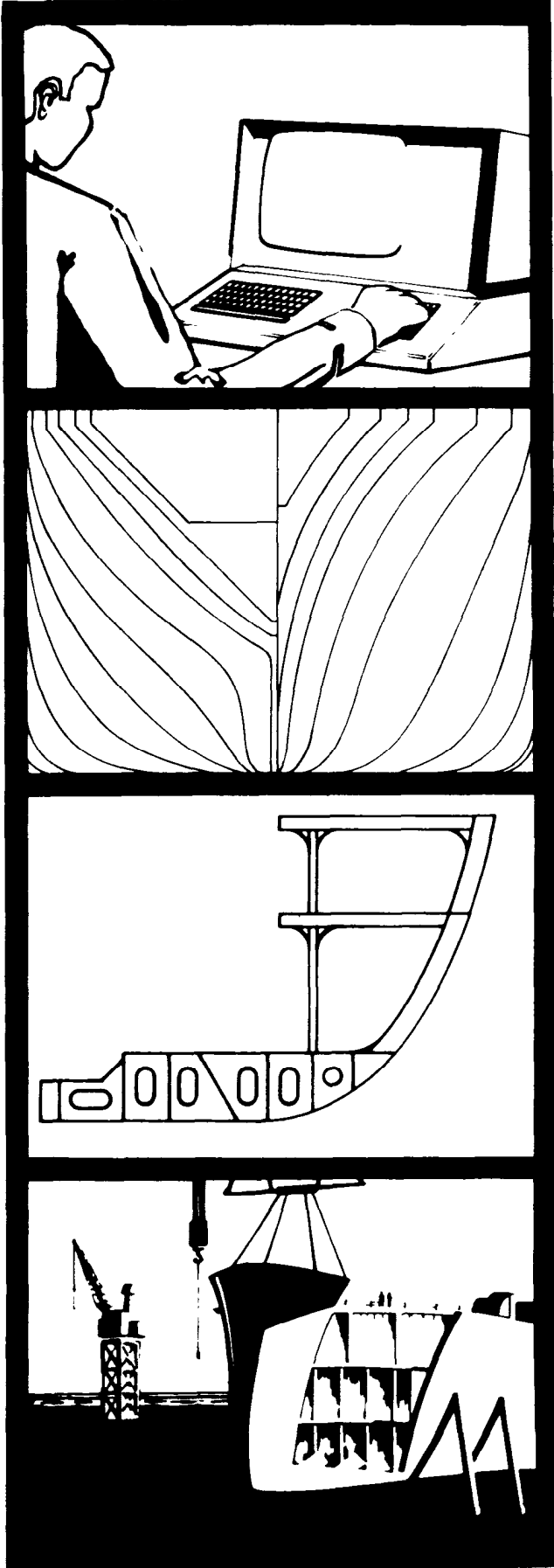
Paper No. 12: Application of Modular Software to Establish a "Closed Loop" System for Shipyard Production Control

U.S. DEPARTMENT OF THE NAVY
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R ESEARCH
E AND
E NGINEERING
A FOR
A UTOMATION
P AND
S RODUCTIVITY
IN
SHIPBUILDING

**Proceedings of the
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**APPLICATION OF MODULAR SOFTWARE TO ESTABLISH
A "CLOSED LOOP" SYSTEM FOR SHIPYARD PRODUCTION CONTROL**

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ABSTRACT

This paper addresses the key functions of a closed-loop production and inventory, and planning control system generally applicable to the shipbuilding industry. A key feature of the shipbuilding closed-loop system is the application of made-to-order concepts not generally used in production and inventory planning, and control systems for other industries. The use of modular packaged software to make the system operational on a timely step-by-step basis are explored. Special considerations for tailoring the software to satisfy general shipbuilding requirements are reviewed. A summary of the potential benefits of a closed-loop system (i.e., "what if" planning) is also included.

Background

The shipbuilding industry presents challenges to its management that are nearly unequalled in other industries. The dimensions of delivered ships exceed the size of comparable end products. Shipyard engineering must define and control several hundred thousand parts for each design. Much of the equipment used in outfitting ships is advanced state-of-the-art technology. To deliver the ships to budget and schedule, extensive efforts are expended to plan and control the required resources. In most cases, ships are built one-at-a-time and, while not always visible, no two ships of a class/contract are exactly the same. Systems to support shipyard management have generally satisfied single management functions (i.e. master planning, engineering, accounting) and relied on analysts, planners, and expeditors to link the functional elements together. In yards with advanced technology shipbuilding programs (typically associated with a high level of contract specification changes), the efforts required to maintain the functional system links expand quickly.

Despite the intense attention of shipyard management to assure the systems support the various building programs, many situations develop in which material or other resources are not available to satisfy the contract/schedule requirements and schedules/budgets are missed.

Evolution of Closed Loop System

Generally, the complications of planning and controlling shipyard efforts parallels the manufacturing industry with the exception of contract focus, technical specification requirements and traceability. In coping with their system requirements, the manufacturing industry promoted the development of a system concept that became viable as computer applications software technology advanced. Originally, this concept was known as MRP (Material Requirements Planning). With field experience, MRP advocates converted this acronym to mean manufacturing resources planning, since not just material had to be planned and controlled to make production goals. Successful MRP systems captured the imagination of top management and the opportunity to integrate the planning and control process from top to bottom via closed loop concepts (feedback communication and data integration) became reality.

Make-To-Order

Interest on the part of manufacturers who make products for the government led to the refinement of Make To-Order concepts and software which address many of the contract and technical requirements of shipbuilding. The

opportunity now exists to apply 'Closed Loop' concepts in shipyards to support management in planning and controlling resources, priorities, and performance to deliver ships on schedule, at planned costs, at the right ROI, and correctly configured.

Because of the size, complexity, inertia of work-in-process, and overall employee reluctance to change, shipyards cannot expect to install a Closed Loop system overnight. Extensive design, planning, and education efforts are required for all levels of the shipyard organization. A practical approach can be adopted to install the Closed Loop system in modules so shock is minimized and experience builds a strong foundation for success. Overall success of the system will be determined by: 1) constant evaluation and response to the feedback mechanisms and 2) a program to continually monitor key system performance factors.

The following schedules explain in more detail the closed loop system, associated Make-To-Order features, what modular software can be used to build the closed loop system and a strategy for installing the modules:

- . Make-To-Order (MTO) Features:
(Schedule #1)
- . Closed loop concept for shipyard production control.
(Schedule #2)
 - Basic Data
 - Top Management planning
 - Operations management planning
 - Operations execution

- Matrix analysis of shipyard closed loop elements to available software modules.
(Schedule X3)
- Installation strategy
(Schedule #4)

SCHEDULE 1
Page 1 of 1

Key features of M-T-0 (make-to-order) include:

- Order pegging to control component parts for a given order or contract.
- Allocation of Inventory to specific contracts or orders.
(Inventory balances may be optionally maintained by receipt or expiration date, user determined cost, vendor or lot data.)
- Component availability analysis by order or contract.
- Mass rescheduling or order cancellation by order or contract.
- Tracking of material issues by order or contract for actual cost purposes (issues from stock in optional data sequence, such as FIFO).
- Maintain bill-of-material user comments for special purposes such as additional engineering change revision information.
- Material lot control through reference identification on inventory transactions by order or contract.
- Order or contract configuration history by reporting the pegged structure, component revision level and actual quantities for closed orders.

"CLOSED LOOP" CONCEPT FOR SHIPYARD PRODUCTION CONTROL

BASIC DATA

<u>BASIC ELEMENTS</u>	<u>FUNCTION</u>	<u>INPUT TO</u>
BILLS OF MATERIAL DATA	Maintain part specifications Define each product on level by level basis - for all functions Maintain product configuration (Hull effectivity)	. Construction Planning/Master Scheduling . Key Event/System Scheduling . Requirements Planning . Inventory Planning . Product Costing . Product Design . CAD/CAM
INVENTORY DATA	Maintain inventory balances and order status data by part and contract	. Requirements Planning . Inventory Control . Purchasing . Performance Accounting . CAD/CAM
ROUTINGS	Maintain specifications for manufacturing process of a part	. Construction Planning . Master Scheduling . Shop Floor Control . CAD/CAM . Product Costing . Performance Accounting

"CLOSED LOOP" CONCEPT FOR SHIPYARD PRODUCTION CONTROL
TOP MANAGEMENT PLANNING

<u>Closed Loop Element</u>	<u>Function</u>	<u>Input to</u>	<u>Feedback</u>
BUSINESS PLANNING - Objectives -	Set overall objectives of company and manage to support those objectives	Production Planning Sales Planning	Bottom line
SALES PLANNING	Plans sales to meet objectives	Production Planning	Market Success
PRODUCTION PLANNING - Resources -	Determine rates and allocate the resources required to meet the company's business objectives and satisfy contract/construction demands.	Master Scheduling · what to schedule · Schedule Adjustments Inventory Plan	Business Planning · Evaluate and adjust the plan
MASTER SCHEDULING - Product -	States production demands in terms of "what", "How Much" and "When". Provides key facility load analysis (Rough cut capacity plan). Interface with master construction/key event/ system schedules.	Materials Requirements Planning · What · How much · When	Production Planning · Realism · Adjust the plan · Adjust the resources

LOT	REP	PRODUCE
RA	ME	NNING

<u>Closed Loop Element</u>	<u>Function</u>	<u>Input to</u>	<u>Feedback</u>
MATERIAL REQUIREMENTS PLANNING - Priority -	Calculates requirements, plans orders and maintains priorities (time phased) using master schedule, bills of material and inventory status.	Inventory Control . Detail Requirements . Planned orders	Master Scheduling . Master Schedule Input
INVENTORY CONTROL - Availability - - Contract Operations Management -	<u>VANILLA</u> Maintains part balance and order status data <u>MTO</u> Explodes order requirements at all levels to support construction schedules Maintains contract and common stock part balance and pegged contract order status Maintains lot control/contract location Maintains contract allocations Drives contract accounting	Capacity Requirements Planning . Detail Order Data for Load Analysis Purchasing .Purchasing Requirements Performance Accounting . Planned/Actual Data	Production Planning . Inventory Status Master Scheduling . Inventory Status . Relieves Master Schedule Material Requirements Planning . Covered Requirements
CAPACITY REQUIREMENTS PLANNING -Ship/Shop/Floor Capacity-	Assists in determination of the most efficient production schedule based on projected facility load.	Production Planning . Load analysis Master Scheduling . Load analysis	Operations Execution Function . Detail Planning for resource check

"CLOSED LOOP" CONCEPT FOR SHIPYARD PRODUCTION CONTROL
OPERATIONS EXECUTION

<u>Closed Loop Element</u>	<u>Function</u>	<u>Input to</u>	<u>Feedback</u>
SHOP FLOOR CONTROL - Schedule Performance -	Executes the plan by controlling Ship/Shop capacity and priorities, reporting contract order status and maintaining delivery, quality and productivity performance.	Performance Accounting	Adjustments for: Master Scheduling Material Requirements Planning Inventory Control Capacity Planning
PURCHASING - Schedule Performance -	Executes the plan by controlling vendor capacity and priorities, reporting purchase order status and maintaining delivery, quality and and cost performance.	Performance Accounting	Adjustments Master Scheduling Material Requirements Planning Inventory Control Capacity Planning
277 PERFORMANCE ACCOUNTING (Cost and Inventory Accounting) - Accountability - - Progress - - Cost at Complete -	Status, maintains and reports key cost, rate and other variance data. Drives progress accounting and cost at complete analysis	All	Master Scheduling Material Requirements Planning Inventory Control Capacity Planning Bill of Material (Design Engineering) Routing data ----- Overall Business Planning

MATRIX ANALYSIS OF SHIPYARD CLOSED LOOP ELEMENTS
TO AVAILABLE SOFTWARE MODULES

<u>CLOSED LOOP ELEMENT</u>	<u>GENERALLY APPLICABLE MODULE</u>	<u>SYSTEM INSTALLATION CONSIDERATIONS</u>
BUSINESS PLANNING	MODELING SYSTEM	NO CHANGES EXPECTED BUT MUST CONTAIN STRATEGIES AND INTEGRATE TO PRODUCTION PLAN
PRODUCTION PLANNING (Contract/Construction Planning)	COST SCHEDULE CONTROL SYSTEM Generally home grown but packages are available	KEY EVENT/SYSTEM SCHEDULING WORK BREAKDOWN STRUCTURE ACTUAL COST AND PROGRESS DATA INTERFACE SCHEDULE MAINTENANCE EXPLOSION/ CAPABILITY

CLOSED LOOP ELEMENTS TO SOFTWARE MODULES

CLOSED LOOP
ELEMENT

GENERALLY
APPLICABLE MODULE

SYSTEM INSTALLATION
CONSIDERATIONS

MASTER SCHEDULING

MASTER SCHEDULING

TECHNIQUE TO INTERFACE WITH
PRODUCTION PLANNING (WORK
PACKAGE) CONTROL SYSTEM

HOW TO MAINTAIN PLANNING BILLS
FOR LONG LEAD MATERIAL

HOW TO PLAN/FORECAST SERVICE
REQUIREMENTS

- SHOPS
- MOLDS, SPECIAL EQUIPMENT,
JIGS, FIXTURES
- SPARES
- OTHER PRODUCTS

ROUGH CUT LOAD ANALYSIS LEVEL FOR
LABOR/MACHINE/FACILITY

HOW TO FORMALLY KEEP OFF HULL
WORK PACED TO ON HULL WORK
(TIME FENCES)

- POLICIES MUST BE STRICT
TO MAINTAIN MOMENTUM
BUT PRACTICAL TO GET
MAXIMUM FROM EQUIPMENT,
MANPOWER AND MATERIAL

CLOSED LOOP ELEMENTS TO SOFTWARE MODULES

<u>CLOSED LOOP ELEMENT</u>	<u>GENERALLY APPLICABLE MODULE</u>	<u>SYSTEM INSTALLATION CONSIDERATIONS</u>
BILLS OF MATERIAL PART SPECIFICATION	DESIGN ENGINEERING	HULL EFFECTIVITY? PLANNING/BID BILLS CONTRACT CHANGES WORK BREAKDOWN STRUCTURE ORDER/WORK PACKAGE CONCEPTS INTERFACES TO CAD/CAM PART SPECIFICATION
INVENTORY DATA AND INVENTORY CONTROL	INVENTORY CONTROL (MTO CAPABILITIES)	ORDER PEGGING AND RELATED NETWORK REQUIREMENTS (MTO Requirements) ORDER LAUNCH AND CONTROL LOT CONTROL/TRACEABILITY CONTRACT ALLOCATIONS INTERFACES TO CAD/CAM STOP WORK NOTIFICATION AND CONTROLS CLOSE OUT MECHANISM

CLOSED LOOP ELEMENTS TO SOFTWARE MODULES

<u>CLOSED LOOP ELEMENT</u>	<u>GENERALLY APPLICABLE MODULE</u>	<u>SYSTEM INSTALLATION CONSIDERATIONS</u>
ROUTINGS	MANUFACTURING ENGINEERING	INTERFACES TO GROUP TECHNOLOGY? HULL APPLICABILITY? QUALITY REQUIREMENTS
MATERIAL REQUIREMENTS	MATERIAL REQUIREMENTS PLANNING	ALLOCATE TO CONTRACTS AND DETER- MINE NET REQUIREMENTS BY CONTRACT MTO/RP INTERFACE
CAPACITY REQUIREMENTS PLANNING	CAPACITY PLANNING	NONE SPECIAL AT INDUSTRY LEVEL
SHOP FLOOR CONTROL	SHOP FLOOR CONTROL	NONE SPECIAL AT INDUSTRY LEVEL
PURCHASING	PURCHASING	GENERALLY HOME GROWN SHOULD ADDRESS BID PROCESS, VENDOR QUALIFICATIONS AND RELIABILITY, AND SPECIAL REPORTING

CLOSED LOOP ELEMENTS TO SOFTWARE MODULES

CLOSED LOOP
ELEMENT

GENERALLY
APPLICABLE MODULE

SYSTEM INSTALLATION
CONSIDERATIONS

PERFORMANCE ACCOUNTING

INVENTORY ACCOUNTING

HOW TO MAINTAIN "BID BILL" BY
CONTRACT AND MEASURE

- ENGINEERING TAKEOFF
VARIANCES
- ACTUAL USAGE VARIANCES

INTEGRATION WITH CONTRACT CHANGE

- FOLLOWUP COST ANALYSIS

CONTRACT ACCOUNTING

PRODUCTION COSTING

USING THE VARIANCES IN MANUFACTURING
TO EVALUATE BID/ESTIMATES

- ESTIMATE
- BID
- PURCHASING
- MATERIAL
- MANUFACTURING (Labor)

MAINTAIN FULL ABSORPTION OF COST
IN PRICED OUT BILLS

- UNIT COST EFFECTIVITY?

CLOSED LOOP SYSTEM FOR SHIPYARD PRODUCTION PLANNING AND CONTROL

INSTALLATION STRATEGY

Step	<u>Modules Addressed</u>	<u>Benefits Anticipated</u>
1	Design Engineering Manufacturing Engineering Manufacturing Engineering	Accurate and timely product engineering information - Bills and routings - Product specification control Hull effective engineering change tracking and control Work package preparation, dispatch and control Minimize manufacturing lead times and related costs by facility usage control
2	Inventory Control/Make To Order	Accurate part balance/contract order status Contract order network control Work packages generation and control Visibility of order/construction status Support schedule definition Contract material location control Historical data maintenance by contract Long lead item control Improved contract change evaluation and control capabilities
3	Master Scheduling Material Requirements Planning	Rough cut validation of construction plan Order planning Control of common manufactured parts Interface with MTO for full BOM control
4	Shop Floor Control	Coordination of schedules at lower level Improved shop scheduling for addressing alternative manufacturing strategies Detail status of manufacturing work Permits input/output control Ship/Shop - QC/NQC interface
5	Capacity Planning	Efficient facility loading Minimize production delays
6	Inventory accounting (Product costing	Variance analysis for improved bids and contract Change support Effective support of progressing and CAC analysis Integrated contract accounting Ties performance to business planning Closes the loop

**APPLICATION OF MODULAR
SOFTWARE TO ESTABLISH A
"CLOSED LOOP" SYSTEM FOR SHIPYARD
PRODUCTION CONTROL**

SHIPBUILDING ENVIRONMENT

- . LEADERS IN ADVANCED TECHNOLOGY PROCESSES**
- . ENVIRONMENTAL AND SAFETY FACTORS EMPHASIZED**
- . MORE OFF HULL WORK**
- . VERTICAL INTEGRATION EXPANDING**
 - MORE OPPORTUNITIES FOR PROFIT**
 - TOLERANCES DIFFICULT TO MEET**
 - HIGH LEVEL OF EXPEDITING**
- . COMPETITIVENESS**
- . MAKE-TO-ORDER FOCUS**

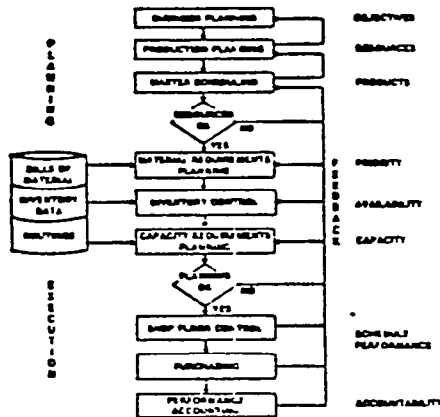
IN A SHIPYARD, WHAT IS A CLOSED LOOP SYSTEM?

**IT IS AN INFORMATION SYSTEM FOR PLANNING AND
CONTROLLING RESOURCES, PRIORITIES, AND PERFORMANCE TO DELIVER
SHIPS.**

- . ON SCHEDULE**
- . AT PLANNED COST**
- . AT THE RIGHT ROI**
- . CORRECTLY CONFIGURED**

SHIPYARD PLANNING AND CONTROL

CLOSED LOOP MANUFACTURING SYSTEM

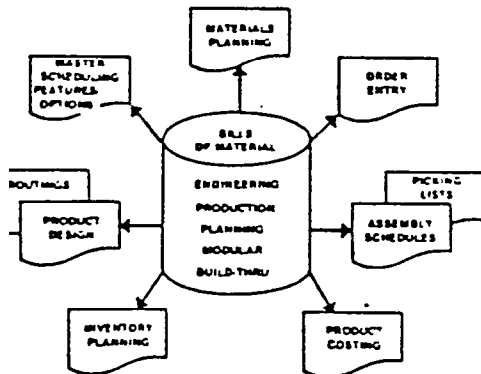


MASTER ROUTING

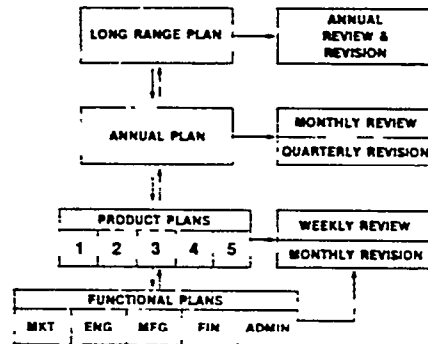
PART NO	DESCRIPTION	UNIT REQ	TYPE CODE	COMP CODE	ENG REV	ENG REV	SALES NO	
AA 01	DOUBLE BOOK SET	EA	000	000	1000	01	AA 01	
SER NO	DESCRIPTION	SER NO	W/C NO	MACH NO	TOOL NO	SETUP HRS	LABOR HRS/PC	RATE CODE
001 00	NOTCH LOCATIONS FOR HINGES PER	000	201	01204	00100	.2	.300	0
002 00	POINT & TOTAL	000	201			.2	.300	0
003 00	ATTACH HINGES TO BOOKS	000	201		00100	.2	.300	0
004 00	SCREW CENTER POST TO LEFT BOOK	000	201		00100	.2	.300	0
005 00	INSPECT	000	200			.2	.100	1
006 00	PACK FOR SHIPPING	000	201		00001	.2	.300	1
TOTAL HOURS						2	1.200	
OPERATIONS REQUIRED TO MAKE PART								

↑ OPERATIONS REQUIRED TO MAKE PART

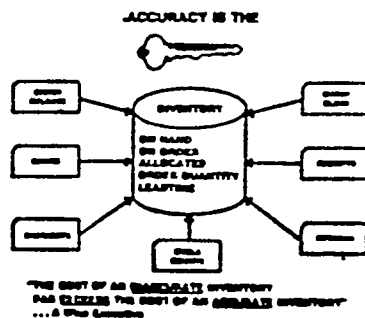
BILL OF MATERIAL USES



BUSINESS PLANNING CYCLE



INVENTORY TRANSACTION CONTROL



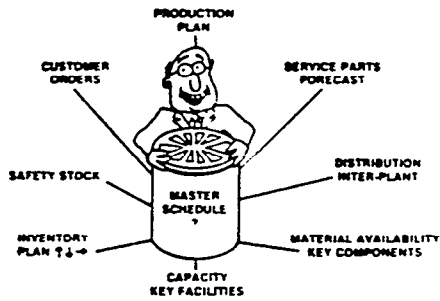
PRODUCTION PLANNING OVERVIEW



ALLOCATE COMPANY RESOURCES TO CAPITALIZE ON THE "BEST" MARKETPLACE OPPORTUNITIES

SHIPYARD PLANNING AND CONTROL

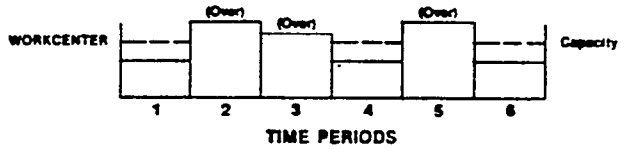
MASTER SCHEDULE INPUT



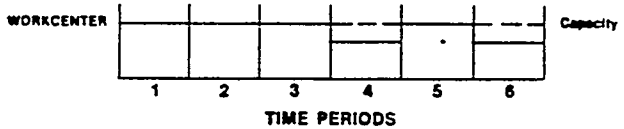
IS MASTER SCHEDULING A BIG JOB? **YES!**
IT IS THE DRIVER FOR MRP

LOADING METHODS

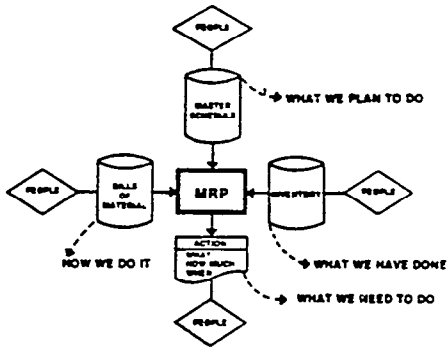
INFINITE - Without Regard For Capacity



FINITE - Not To Exceed Capacity

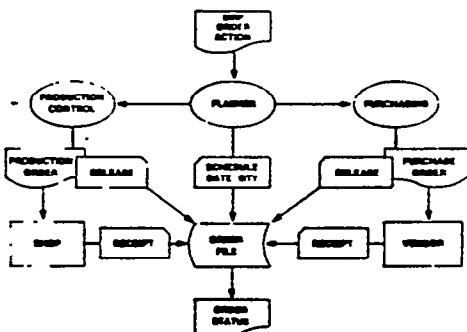


MRP SYSTEM OVERVIEW



**“A PLAN THAT EXCEEDS
CAPACITY
WILL NOT GET PRODUCED
AND
WILL BUILD INVENTORY”**

PRODUCTION & PURCHASE ORDER CONTROL



PRIORITY DISPATCH LIST										DATE 6-30-1
WORK CENTER	PART NO	ORDER NO	OPER NO	ORDER	QUANTITY	COMPLETE	BALANCE	HOURS	SCHEDULE START	DUE
102	*AA02	12333	010	10	0	10	5	5	6-27-X	6-27 X
	AA10	12444	020	25	0	25	5	5	6-30-X	6-30 X
	*AA01	12345	020	100	50	50	50	50	7-01-X	7-07 X

WORKCENTER / START DATE SEQUENCE

* AVAILABLE AT WORK CENTER

SHIPYARD PLANNING AND CONTROL

INPUT-OUTPUT CONTROL

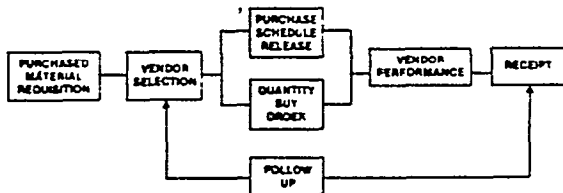
		WEEK			
		1	2	3	4
INPUT CRP	PLANNED	260	260	260	260
	ACTUAL	260	255	260	
	CUMM DEVIATION	0	-5	-5	
OUTPUT SFC	PLANNED	290	290	290	290
	ACTUAL	295	250	270	
	CUMM DEVIATION	+5	-35	-55	
BACKLOG STATUS	PLAN	300	270	240	210
	ACTUAL	265	270	260	

A PLAN THAT EXCEEDS CAPACITY WILL NOT GET PRODUCED

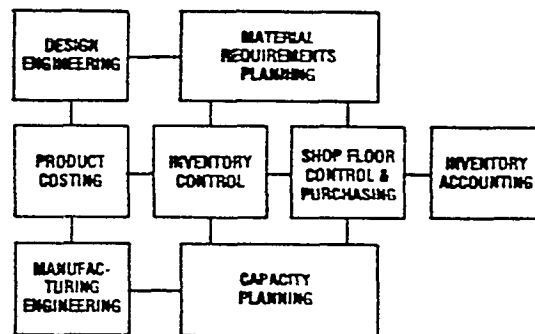
PERFORMANCE MEASUREMENT

PERFORMANCE AREA		RESPONSIBILITY
BILL OF MATERIAL		ENGINEERING
PERFORMANCE CRITERIA	PERFORMANCE MEASUREMENT	MEASUREMENT METHOD
PRODUCT STRUCTURE	PARTS QUANTITIES, LEVEL BY LEVEL FOR ASSEMBLY	PULL PARTS AND ASSEMBLE
ENGINEERING CHANGE CONTROL	PLANNED AND ACTUAL EFFECTIVITY RATES	WEEKLY BOM EFFECTIVITY STATUS REPORT
OBSOLETE INVENTORY	OBSOLETE INVENTORY AMT % OF TOTAL INVENTORY	QUARTERLY OBSOLETE INVENTORY ANALYSIS REPORT

PURCHASING FLOW



MAC-PAC MANUFACTURING PLANNING AND CONTROL SYSTEM



PERFORMANCE QUESTIONS

- WHAT IS THE PERFORMANCE?
- WHAT SHOULD IT BE?
- WHAT IS PERFORMING?
- WHAT IS NOT?
- WHAT ACTION IS REQUIRED?
- WHO IS RESPONSIBLE?
- WHEN WILL IT BE DONE?
- WHAT IS THE FOLLOW-UP?

CLASS A, B, C, D USERS

SYSTEM CLASSIFICATION	SYSTEM PERFORMANCE	SYSTEM CHARACTERISTICS
A	95%	COMPLETE CLOSED LOOP SYSTEM. TOP MANAGEMENT USES THE FORMAL SYSTEM TO RUN THE BUSINESS. ALL ELEMENTS AVERAGE 80% TO 100%.
B	85%	FORMAL SYSTEM IN PLACE BUT ALL ELEMENTS ARE NOT WORKING EFFECTIVELY. TOP MANAGEMENT APPROVES BUT DOES NOT PARTICIPATE. ELEMENTS AVERAGE 60% TO 80%.
C	70%	ERP IS ORDER LAUNCHING RATHER THAN PLANNING. PRIORITIES, FORMAL AND INFORMAL SYSTEM ELEMENTS ARE NOT TIED TOGETHER. SOME SUB-SYSTEMS NOT IN PLACE. ELEMENTS AVERAGE 50% TO 70%.
D	50%	FORMAL SYSTEM NOT WORKING, OR NOT IN PLACE. POOR DATA INTEGRITY. LITTLE MANAGEMENT INVOLVEMENT. LITTLE USER CONFIDENCE IN SYSTEM. ELEMENTS ARE 50% OR BELOW.

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